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# Biophysical Strategic Agricultural Land Assessment

# Bulga Optimisation Project – Modification Area

Report Number 630.11560

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Umwelt (Australia) Pty Ltd
75 York Street
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Version: Final

# Biophysical Strategic Agricultural Land Assessment

# Bulga Optimisation Project – Modification Area

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# 1 INTRODUCTION

Umwelt (Australia) Pty Limited engaged SLR Consulting Australia Pty Ltd (SLR) to undertake a Biophysical Strategic Agricultural Land (BSAL) Assessment for the Bulga Coal Complex modification of the Proposed Eastern Emplacement Area, which comprises part of the Bulga Optimisation Project and is located approximately 5 kilometres south east of Mount Thorley in the Upper Hunter Valley.

Bulga Coal Management is proposing to modify the design of the Eastern Emplacement Area which was approved as part of the Bulga Optimisation Project, and as such are required to complete a BSAL Assessment to obtain a Site Verification Certificate as per *Part 4AA* of the *Division 3 of State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007*. The modification of the Proposed Eastern Emplacement Area, referred to as the Site Verification Study Area (89 hectares) is shown in **Figure 1**.

## 1.1 Study Area

The Study Area for this BSAL Assessment is the modification of the Proposed Eastern Emplacement Area (89 hectares), plus a 100 metre buffer totalling 143 hectares (**Figure 2**). The Study Area is not mapped as BSAL according to the NSW Government (DP&I, 2012).

Preliminary desktop assessment found the Study Area is covered by the Rothbury Soil Landscape Unit (Kovac and Lawrie, 1991), which is dominated by the Australian Soil Classification (ASC) type Kurosol. Kurosols are soils that have a strong texture contrast between the topsoil and subsoil horizons with strongly acidic subsoils and have moderate to moderately low inherent fertility. The Study Area has been digitally mapped by the Office of Environment and Heritage (OEH) as Land and Soil Capability (LSC) Class 5. LSC Class 5 is moderately low capability land with high limitations for high-impact agricultural land uses and is largely restricted to grazing, orchards, forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation.

## 1.2 Legislation and Standards

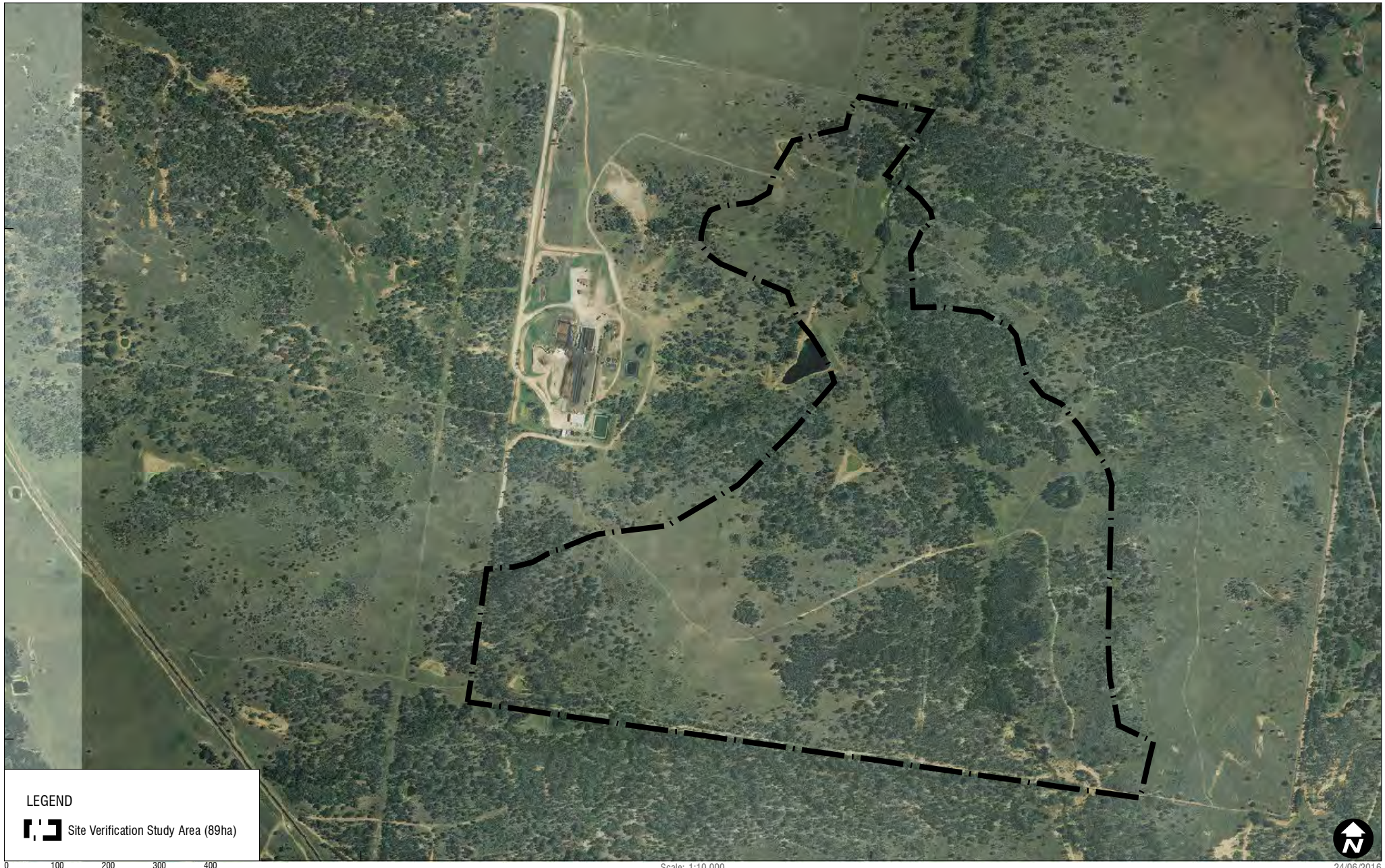
### 1.2.1 Interim Protocol for Site Verification and Mapping of BSAL

In April 2013, the *Interim Protocol for Site Verification and Mapping of Biophysical Strategic Agricultural Land* (Interim Protocol) ((Office of Environment & Heritage (OEH) and Department of Primary Industries - Office of Agricultural Sustainability and Food Security (DPI-OASFS), 2013)) was released by the NSW Government. This Interim Protocol outlines the process for seeking verification of whether or not land mapped as BSAL meets the Interim Protocol's BSAL criteria. The *State Environment Planning Policy (Mining, Petroleum Production and Extractive Industries) Amendment 2013* (the 2013 Mining SEPP amendment) requires certain types of developments to verify whether the proposed site is on BSAL.

## 1.3 Assessment Standards

The key standards for this assessment include:

- Interim Protocol.
- Australian Soil Classification (ASC) system (Isbell, 1996).
- Guidelines for Surveying Soil and Land Resources (NCST, 2008).
- Australian Soil and Land Survey Field Handbook (NCST, 2009).

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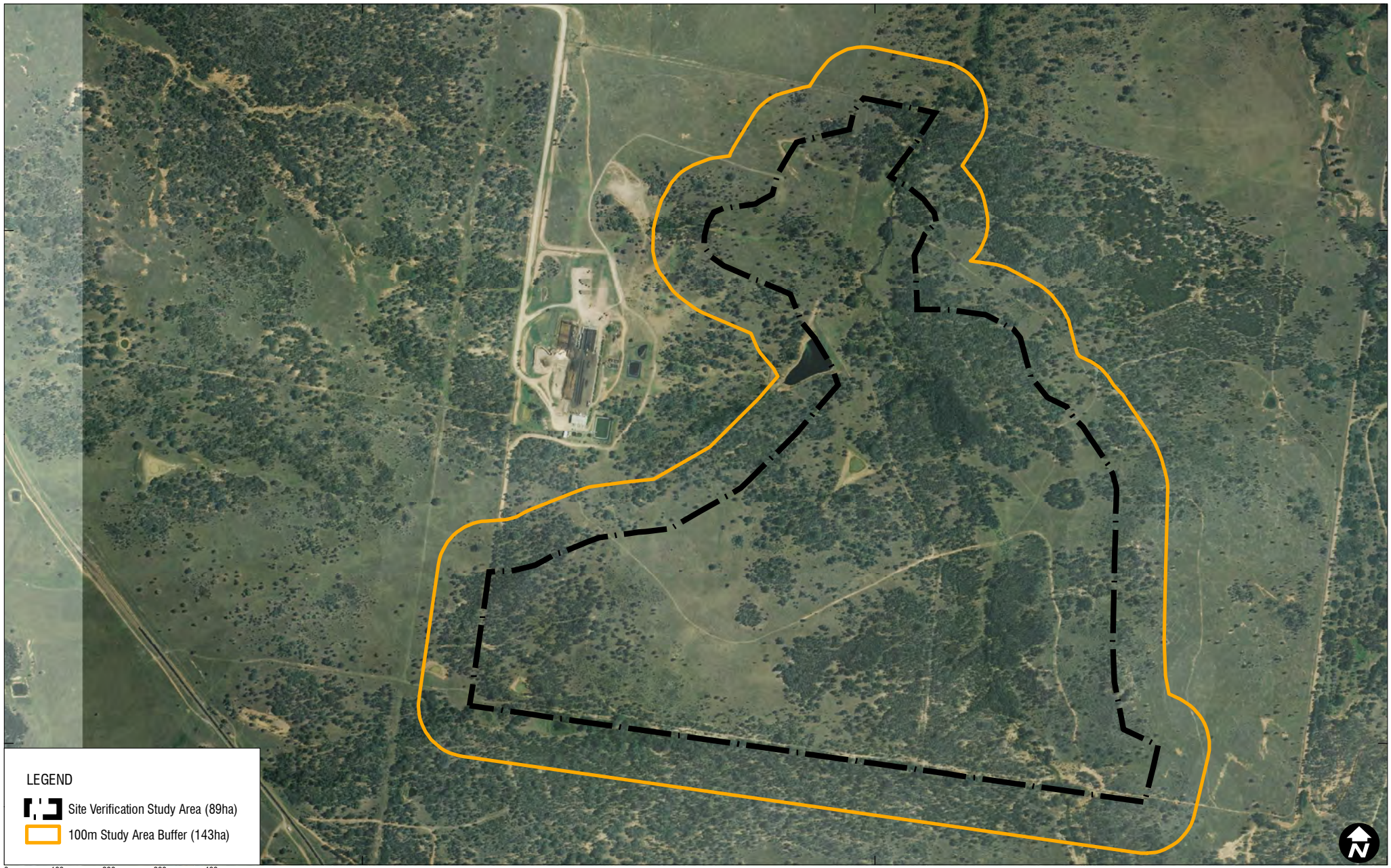
## Site Layout

**FIGURE 1**

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**BSAL Study Area**

**FIGURE 2**

# 2 METHODOLOGY

The site verification and methodology for the Study Area reported in the following sections has been undertaken based on the Interim Protocol; including the following steps:

1. Identify the project area (termed Study Area in this report) which will be assessed for BSAL;
2. Confirm access to a reliable water supply;
3. Choose the appropriate approach to map the soils information;
4. Risk assessment; and
5. Field Soil Survey and BSAL Assessment.

## 2.1 Step 1: Identify the project area which will be assessed for BSAL

The Interim Protocol requires that:

> *"The assessment area should include the entire project area and include at least a 100 m buffer to take into account minor changes in design, surrounding disturbance and minor expansion. If BSAL is part of a larger contiguous mass of BSAL then the boundary of this area must also be identified."*

The Study Area for this BSAL Assessment is shown in **Figure 2** which includes a 100 metre buffer surrounding the Study Area, totalling 143 hectares.

## 2.2 Step 2: Confirm access to a reliable water supply

The Interim Protocol requires that:

> *"BSAL lands must have access to a reliable water supply."*

Representative rainfall data for the Study Area has been obtained from the nearest Bureau of Meteorology (BOM) weather station located at Bulga. The Bulga BOM Station (061143) has recorded an average annual rainfall of 699.6 mm (based on records from 1963 – present); therefore the Study Area meets the minimum average annual rainfall of 350 mm to have access to reliable water supply.

## 2.3 Step 3: Choose the appropriate approach to map the soils information

The Interim Protocol states that:

> *"Access to the project area will define the level of investigation that the proponent can undertake. If the proponent has access to the land then the BSAL verification requirements for on-site soils assessment as described in sections 6 and 9 of the Interim Protocol should be met. If the proponent does not have access then the proponent should develop a model of soils distribution guided by sections 6 and 9 based on landscape characteristics using the information listed in Section 5 of the Interim Protocol."*

The Proponent has reasonable access to the majority of the Study Area, however some land access was also constrained by physical access due to slopes and forested terrain. Where land access is not available, soil distribution will be based on landscape characteristics in accordance with the *Interim Protocol*.

## 2.4 Step 4: Risk assessment

The Interim Protocol states that:

> *"The proponent should undertake a risk assessment as this will influence the density of soil sampling required as explained in Section 9.6.1. The proposed activity on parts or all of the project area may be of low risk to agriculture and so may only require a sampling density of 1:100 000. Alternatively other areas may be at higher risk of impact and so should have a sampling density of 1:25 000."*

The Project consists of the construction of an emplacement area and SLR has assessed the following potential impacts of the project activities within the Study Area on agriculture:

- Consequence: Level 2 – Significant and/or long term impact to agricultural resources or industries with long term management implications
- Probability: A – Almost certain.

The risk matrix result was A2 which is considered a high risk. The Study Area therefore requires an inspection density of 1:25,000.

For the purpose of this survey the 100 metre buffer area is also considered to require an inspection density of 1:25,000.

## 2.5 Step 5: Field Soil Survey and BSAL Assessment

Murray Fraser (Senior Agronomist) undertook the fieldwork and sampling during January 2016, supervised by Clayton Richards (CPSS 2). Murray conducted the BSAL Assessment while Clayton was responsible for technical review of the BSAL Assessment.

## 2.6 Field Soil Survey Methodology

For soil to be classified as BSAL it must follow the criteria outlined in the flow chart shown in **Diagram 1**. If any criteria is not met (except step 5 or step 6), the site is not BSAL and there is no need to continue the assessment. The design of the soil survey was developed following a process of applying the BSAL methodology as a desktop exercise to identify any areas that would obviously not meet the criteria (termed exclusion zones). The field survey program was then developed to ensure that areas of relatively higher likelihood of meeting BSAL criteria were targeted for field analysis.

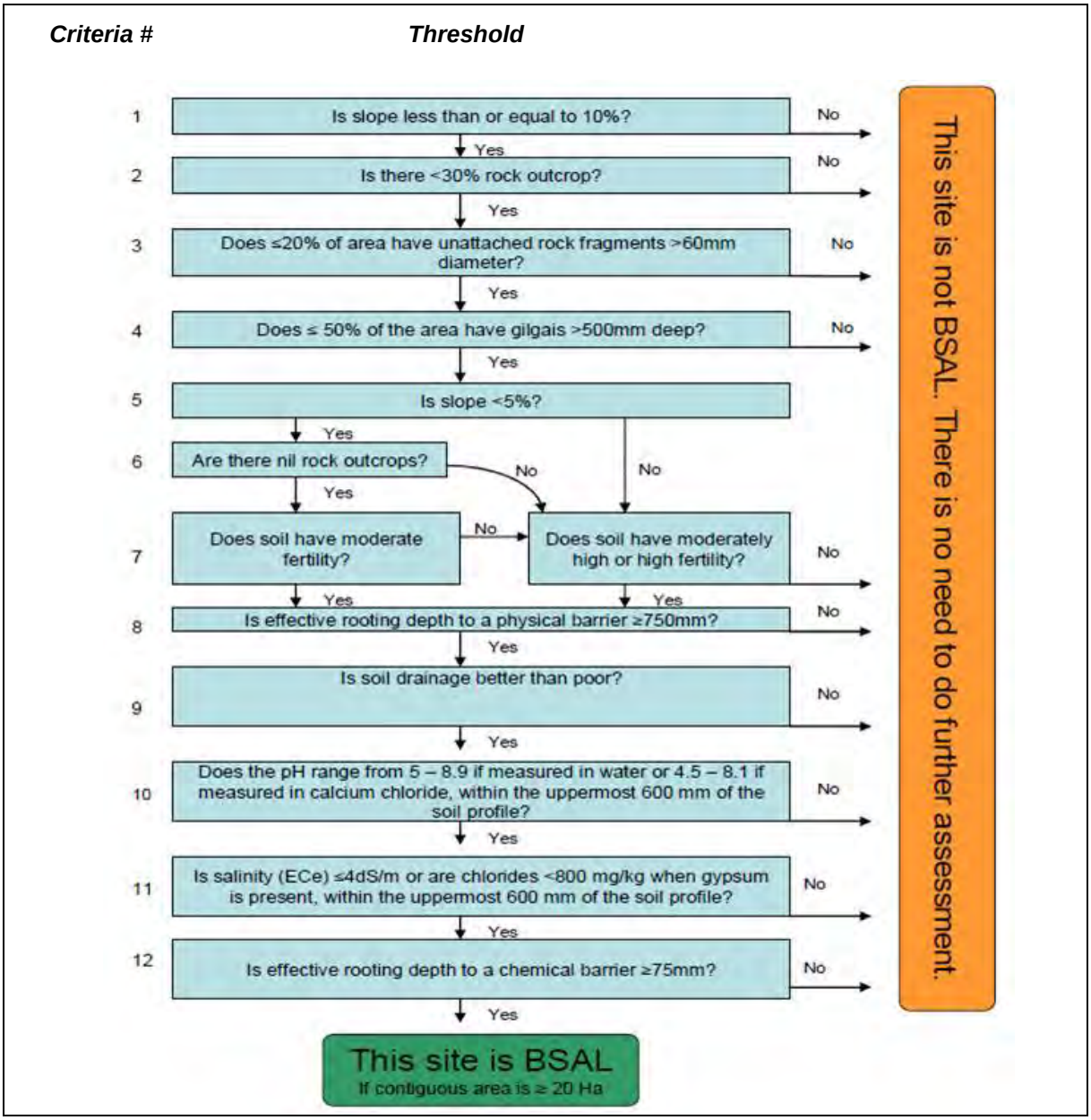
### 2.6.1 Exclusion Zones

Initially, land greater than 10% slope (**Figure 3**) within the Study Area was identified using topographical data from the LIDAR data. Areas with slope greater than 10% slope were excluded. In total 37 hectares was determined not to meet the BSAL methodology Criteria 1 (**Figure 3**). Slope Analysis methodology is provided in **Appendix B**.

Subsequently, any land that did not meet the minimum 20 hectares of contiguous area to be classified as BSAL was also excluded (3 hectares). In total 40 hectares was determined not to meet the BSAL methodology Criteria 1 within the Study Area (**Figure 3**). Land contiguous to the Study Area was taken into consideration when classifying areas of land to be less than 20 hectares.

In summary, 40 hectares were determined not to meet the BSAL methodology criteria within the Study Area. This comprised 37 hectares of land with slope greater than 10% and 3 hectares of land less than 20 hectares contiguous area. This reduced the land to be assessed by the field soil survey program to 103 hectares. (**Table 1** and **Figure 3**).

**Diagram 1 BSAL Soil Laboratory Analysis Parameters**



### 1.1.1 Soil Survey Density

To satisfy the Interim Protocol requirements, the field soil survey program was comprised of 10 observations which consisted of 7 detailed sites and 3 check sites (**Figure 3**).

**Table 1 Soil Survey Density**

| Survey Area | Hectares | Survey Scale | Protocol Required Sites | Sites Completed |
|---|---|---|---|---|
| <10% slope & >20 hectares | 103 | 1:25,000 | 3* | 10 |
| >10% Slope | 37 | N/A | - | - |
| <20 hectares contiguous | 3 | N/A | - | - |
| **Total** | **143** | **-** | **3*** | **10** |

* A minimum of 3 observation sites per soil mapping unit (Soil Unit) are required according to the Interim Protocol

### 1.1.2 Soil Survey Observation Types

*Detailed Sites*

Soil profiles were assessed in accordance with the *Australian Soil and Land Survey Field Handbook* (NCST, 2009). Each soil-profile exposure was pit excavated with a backhoe to a depth of 1.2 metres. After assessment, pits were backfilled with the remaining soil. Detailed soil profile morphological descriptions recorded information that covered the parameters specified in the Interim Protocol.

Samples were sent to the Scone Research Centre (NSW, Australia) for analysis for the suite of parameters as listed in **Table 2**. This laboratory is National Association of Testing Authority (NATA) accredited. Certificates of Analysis are contained in **Appendix A**.

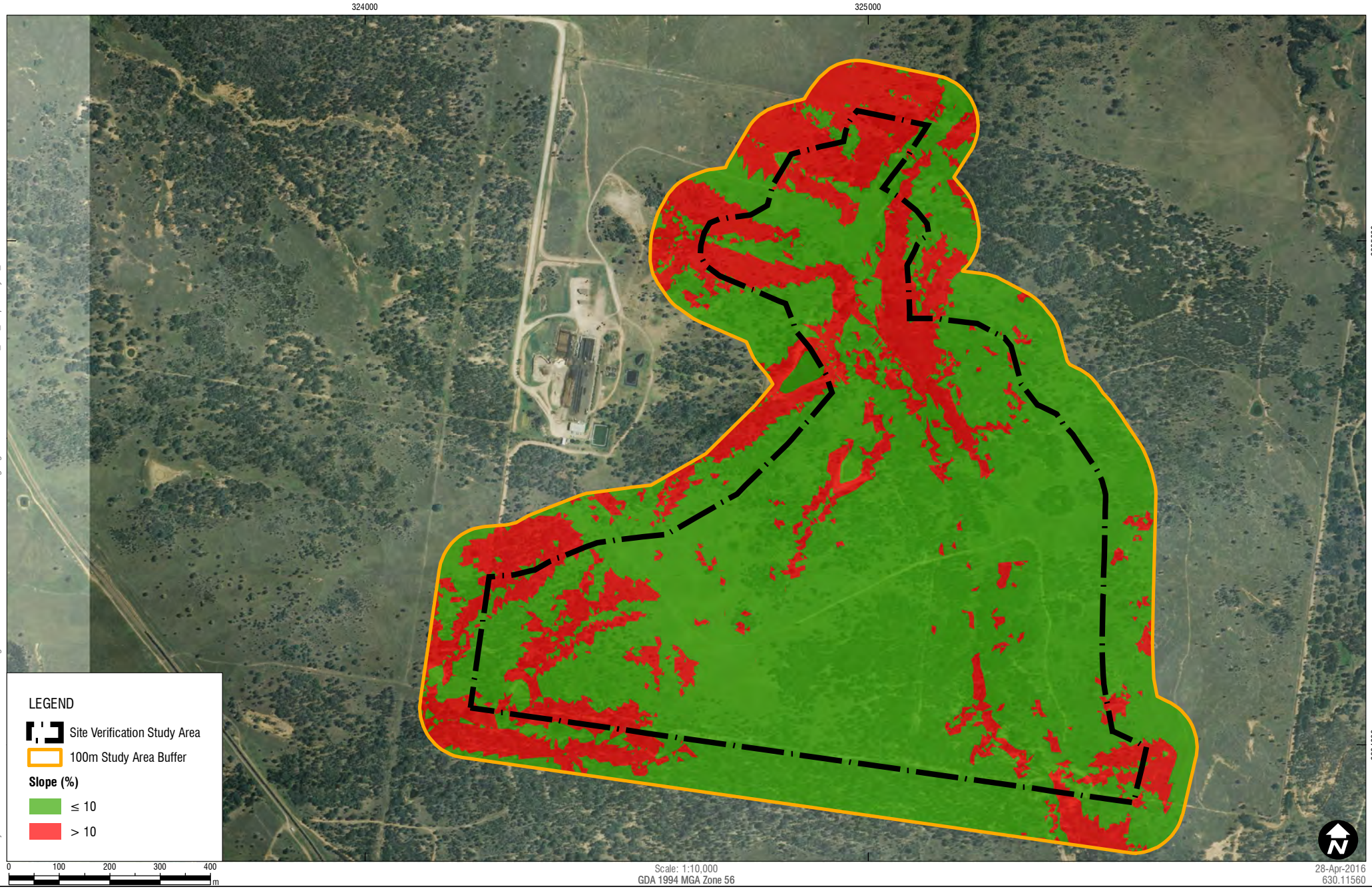
**Table 2 BSAL Soil Laboratory Analysis Parameters**

| Laboratory Analysis | |
|---|---|
| • Electrical conductivity (EC)<br>• pH (1:5)<br>• Total cation exchange and exchangeable cations | • Cation exchange capacity (CEC)<br>• Particle size Analysis<br>• Munsell colour |
| | |

Soil salinity data was determined through measurement of electrical conductivity (EC) of soil:water (1:5) suspensions. These values are converted to the EC of a saturated extract (ECe) based on soil texture in accordance with the Interim Protocol.

*Check Sites*

Check sites are mapping observations examined in sufficient detail to allocate the site to a specific soil type and map unit.

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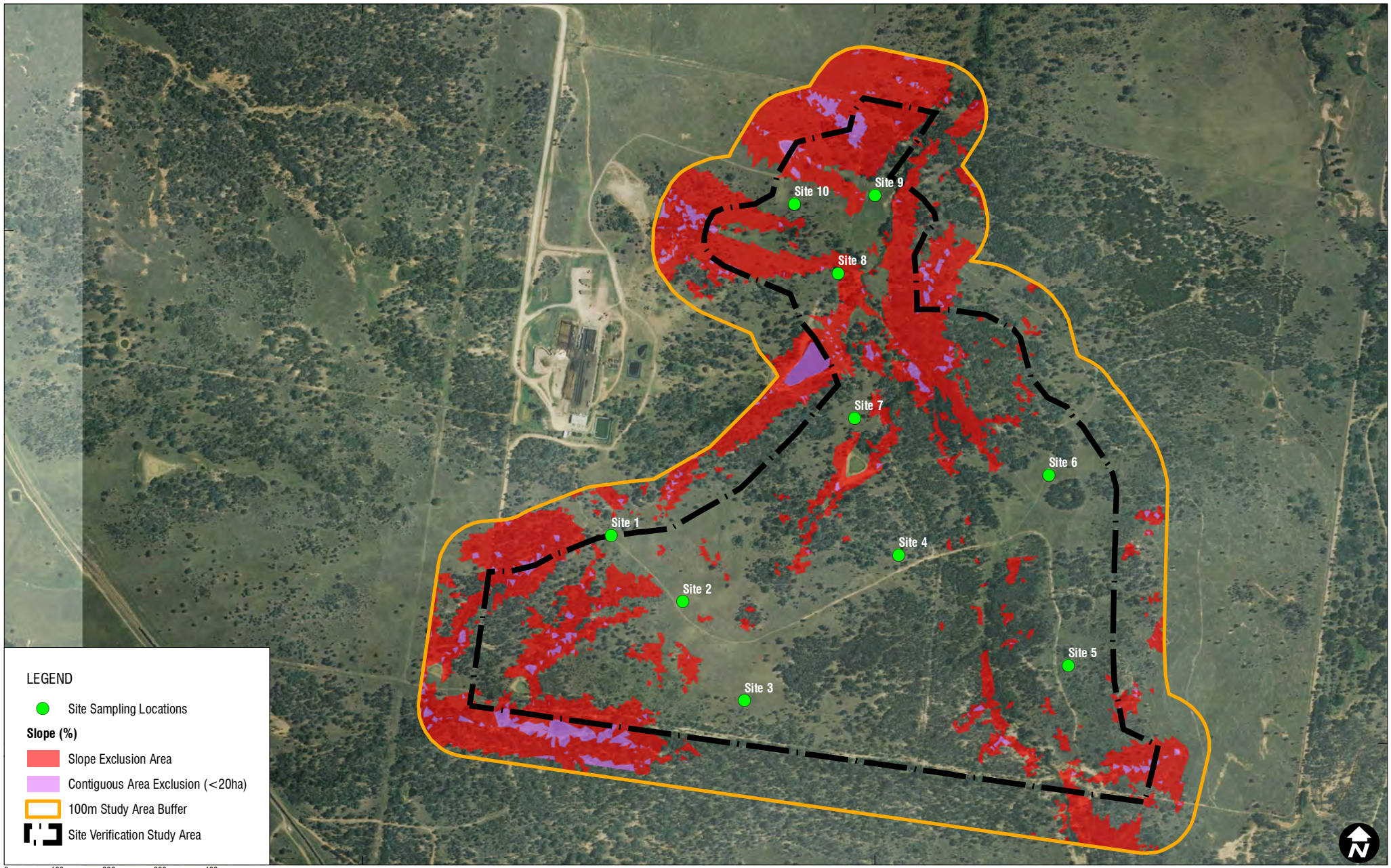
**Slope Analysis**

**FIGURE 3**

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## Sampling Locations & Exclusion Areas

**FIGURE 4**

# 3 SOILS ASSESSMENT

In accordance with the Interim Protocol, a soil mapping unit (Soil Unit) may contain some soil variation, but will typically only contain a single dominant soil type. The dominant soil type will comprise greater than 70% of the Soil Unit. Therefore, a Soil Unit may contain a dominant soil type as well as subdominant and/or soil variants. When a Soil Unit does not have a clear dominant soil type soil variation must be accepted.

Within the Study Area two Soil Units have been identified based on the dominant soil type (**Table 3**; **Figure 4**), a Chromosol and a Sodosol.

**Table 3 Soils Assessment Summary**

| Soil Unit | Soil Type | Area | Survey Type | Site # |
|---|---|---|---|---|
| 1 Chromosol | Dominant: Red Chromosol | 17 Hectares | Detailed | 1, 2 |
| | | | Check | Nil |
| | Sub-Dominant: Brown Chromosol | | Detailed | 4 |
| | | | Check | Nil |
| 2 Sodosol | Dominant: Brown Sodosol | 86 Hectares | Detailed | 5, 6, 8 |
| | | | Check | 9, 10 |
| | Sub-Dominant: Red Sodosol | | Detailed | 3 |
| | | | Check | 7 |
| | | | | |

Three soil profiles from the dominant soil type of Soil Unit 1 (**Section 3.1**) and seven profiles from Soil Unit 2 (**Section 3.2**) are described below.

## 3.1 Soil Unit 1: Eutrophic Red Chromosol

Soil Unit 1 is a Eutrophic Red Chromosol. Chromosols are soils with a strong texture contrast between the A and B horizons, where the B horizon is not strongly acidic or sodic. Within the Study Area Soil Type 1 showed little variance in physical and chemical parameters. Profiles consisted of loamy sand A horizons with a clear boundary to a medium-heavy clay B horizons. All profiles were non-sodic and non-saline, with the exception of Site 4 which was marginally saline at 50-60 cm.

Three representative sites for Soil Unit 1 are described below.

**Table 4 Summary: Eutrophic Red Chromosol (Site 1)**

| **Overview** | |
|---|---|
|  | |
| **Landscape Site 1** | |
| **ASC Name** | Eutrophic Red Chromosol |
| **Representative Site** | Site 1 |
| **Survey Type** | Detail |
| **Dominant Topography** | Hillcrest Plateau |
| **Dominant Land Use** | Cattle Grazing |
| **Vegetation** | Casuarina, Lantana, Grevillea |
| **Inherent Soil Fertility** | Moderately High |
| **Slope** | 7% |

**Table 5 Profile: Eutrophic Red Chromosol (Site 1)**

| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|  | A1<br>0.0 – 0.15 | Dark brown (7.5YR 3/4) loamy sand, weakly structured 2-5 mm crumb peds with weak consistence and a rough fabric.<br>Nil mottling, nil stone content, abundant fine roots. Moderately drained with a gradual and even boundary. |
| | A2<br>0.15 – 0.35 | Strong brown (7.5YR 4/6) loamy sand, weakly structured 5-10 mm crumb peds with weak consistence and a rough fabric.<br>Nil mottling, <5% pebbles 10-20 mm, abundant fine roots. Moderately drained with a clear and even boundary. |
| | B21<br>0.35 – 0.50 | Yellowish red (5YR 5/8) medium clay, moderately structured 20-40 mm subangular blocky peds with moderate consistence and a rough fabric.<br>30% distinct yellow mottles; nil stone content, few coarse roots. Poorly drained with a gradual and even boundary. |
| | B22<br>0.50 – 0.90 | Strong brown (7.5YR 5/8) medium clay, moderately structured 40-80 mm subangular blocky peds with moderate consistence and a rough fabric.<br>30% distinct yellow and 30% distinct red mottles, nil stone content, few coarse roots. Poorly drained with a gradual and even boundary. |
| | BC<br>+0.90 | Weathered parent material |



**Table 6 Chemical Parameters: Eutrophic Red Chromosol (Site 1)**

| Layer (cm) | pH (1:5 water) | | ESP | | ECe (1:5) | | CEC | |
|---|---|---|---|---|---|---|---|---|
| | Unit | Rating | % | Rating | dS/m | Rating | cmol/kg | Rating |
| 0-10 | 6.1 | Slightly Acidic | 3.2 | Non-sodic | 0.2 | Non-saline | 6.2 | Low |
| 20-30 | 6.5 | Slightly Acidic | 3.3 | Non-sodic | 0.1 | Non-saline | 6.0 | Very Low |
| 40-50 | 5.7 | Moderately Acidic | 1.7 | Non-sodic | 0.2 | Non-saline | 18.0 | Moderate |
| 50-60 | 5.7 | Moderately Acidic | 2.4 | Non-sodic | 0.3 | Non-saline | 16.9 | Moderate |
| 65-75 | 5.6 | Moderately Acidic | 2.3 | Non-sodic | 0.2 | Non-saline | 17.2 | Moderate |

**Table 7 Summary: Eutrophic Red Chromosol (Site 2)**

| Overview | |
|---|---|
|  | |
| **Landscape Site 2** | |
| **ASC Name** | Eutrophic Red Chromosol |
| **Representative Site** | Site 2 |
| **Survey Type** | Detail |
| **Dominant Topography** | Hillcrest Plateau |
| **Current Land Use** | Cattle Grazing |
| **Vegetation** | Casuarina, Lantana, Wiregrass, Saffron Thistle |
| **Inherent Soil Fertility** | Moderately High |
| **Slope** | 7% |

**Table 8 Profile: Eutrophic Red Chromosol (Site 2)**

| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|  | A1<br>0.0 – 0.10 | Brown (7.5YR 4/4) loamy sand, weak crumb structure 1-5 mm peds with weak consistence and a rough fabric.<br>Nil mottling. <5% pebbles 10-20 mm, abundant fine roots. Well drained with a gradual and even boundary. |
| | A2<br>0.10 – 0.30 | Strong brown (7.5YR 4/6) loamy sand, weak crumb structure 2-10 mm peds with weak consistence and a rough fabric.<br>Nil mottling, 5% pebbles 10-20 mm, abundant fine roots. Well drained with a clear and wavy boundary. |
| | B21<br>0.30 – 0.40 | Red (2.5YR 4/8) medium clay, moderate structure of 20-40 mm subangular blocky peds with a moderate consistence and a rough fabric.<br>20% distinct yellow mottles, nil stone content, few coarse roots. Moderately drained with a gradual and wavy boundary. |
| | B22<br>0.40 – 0.60 | Yellowish red (5YR 4/6) clay loam, moderate structure of 40-80 mm subangular blocky peds with a strong consistence and a rough fabric.<br>30% distinct yellow mottles, <10% pebbles 10-20 mm, few coarse roots. Poorly drained with a clear and wavy boundary. |
| | BC<br>+0.60 | Weathered parent material |

**Table 9 Chemical Parameters: Eutrophic Red Chromosol (Site 2)**

| Layer (cm) | pH (1:5 water) | | ESP | | ECe (1:5) | | CEC | |
|---|---|---|---|---|---|---|---|---|
| | Unit | Rating | % | Rating | dS/m | Rating | cmol/kg | Rating |
| 0-10 | 5.8 | Moderately Acidic | 4.2 | Non-sodic | 0.1 | Non-saline | 4.8 | Very Low |
| 20-30 | 6.1 | Slightly Acidic | 2.8 | Non-sodic | 0.1 | Non-saline | 7.1 | Low |
| 30-40 | 5.8 | Moderately Acidic | 1.6 | Non-sodic | 0.1 | Non-saline | 18.7 | Moderate |
| 50-60 | 7.3 | Neutral | 1.0 | Non-sodic | 1.4 | Non-saline | 19.1 | Moderate |

**Table 10 Summary: Eutrophic Brown Chromosol (Site 4)**

| Overview | |
|---|---|
|  | |
| **Landscape Site 4** | |
| **ASC Name** | Eutrophic Brown Chromosol |
| **Representative Site** | Site 4 |
| **Survey Type** | Detail |
| **Dominant Topography** | Mid Hillslope |
| **Current Land Use** | Cattle Grazing |
| **Vegetation** | Casuarina, Lantana, Panic |
| **Inherent Soil Fertility** | Moderately High |
| **Slope** | 8% |

**Table 11 Profile: Eutrophic Brown Chromosol (Site 4)**

| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|  | A1<br>0.0 – 0.15 | Brown (7.5YR 3/3) loamy sand, weak crumb structure 1-5 mm peds with weak consistence and a rough fabric.<br>Nil mottling, nil stone content, abundant fine roots. Well drained with a gradual and even boundary. |
| | A2<br>0.15 – 0.30 | Strong brown (7.5YR 4/6) bleached loamy sand, weak crumb structure 2-10 mm peds with weak consistence and a rough fabric.<br>Nil mottling, <5% pebbles 10-20 mm, abundant fine roots. Well drained with a clear and wavy boundary. |
| | B21<br>0.30 – 0.50 | Dark yellowish brown (10YR 4/6) heavy clay, moderate structure of 20-40 mm subangular blocky peds with a moderate consistence and a rough fabric.<br>30% distinct yellow mottles, nil stone content, few coarse roots. Poorly drained with a gradual and wavy boundary. 20% hard calcium nodules 10 mm. |
| | B22<br>0.50 – 0.90 | Strong brown (7.5YR 5/8) light clay, moderate structure of 40-80 mm subangular blocky peds with a strong consistence and a rough fabric.<br>40% distinct yellow mottles, <5% pebbles 10-20 mm, few coarse roots. Poorly drained with a clear and wavy boundary. 30% hard calcium nodules 10 mm. |
| | BC<br>+0.90 | Weathered parent material |

**Table 12 Chemical Parameters: Eutrophic Brown Chromosol (Site 4)**

| Layer (cm) | pH (1:5 water) | | ESP | | ECe (1:5) | | CEC | |
|---|---|---|---|---|---|---|---|---|
| | Unit | Rating | % | Rating | dS/m | Rating | cmol/kg | Rating |
| 0-10 | 5.1 | Strongly Acidic | 1.6 | Non-sodic | 0.1 | Non-saline | 6.4 | Low |
| 20-30 | 5.6 | Moderately Acidic | 3.7 | Non-sodic | 0.1 | Non-saline | 5.4 | Very Low |
| 35-45 | 6.4 | Slightly Acidic | 4.4 | Non-sodic | 0.7 | Non-saline | 25.0 | Moderate |
| 50-60 | 8.4 | Moderately Alkaline | 4.2 | Non-sodic | 2.0 | Slightly Saline | 31.1 | High |
| 65-75 | 8.7 | Strongly Alkaline | 4.6 | Non-sodic | 1.5 | Non-saline | 26.2 | High |

## 3.2 Soil Unit 2: Subnatric Brown Sodosol

Soil Unit 2 is a Subnatric Brown Sodosol. Sodosols are soils with a strong texture contrast between the A horizon and a sodic B horizon which is not strongly acidic. Within the Study Area Soil Type 2 showed little variance in physical and chemical parameters. Profiles were generally loamy sand in the A horizons with a clear boundary to a light-medium clay B horizons.

Seven representative sites for Soil Unit 2 are described below.

**Table 13 Summary: Subnatric Brown Sodosol (Site 5)**

| Overview | |
|---|---|
|  | |
| **Landscape Site 5** | |
| **ASC Name** | Subnatric Brown Sodosol |
| **Representative Site** | Site 5 |
| **Survey Type** | Detail |
| **Dominant Topography** | Lower Hillslope |
| **Current Land Use** | Cattle Grazing |
| **Vegetation** | Casuarina, Acacia, Pigeon Grass |
| **Inherent Soil Fertility** | Moderately Low |
| **Slope** | 7% |

**Table 14 Profile: Subnatric Brown Sodosol (Site 5)**

| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|  | A1<br>0.0 – 0.15 | Dark yellowish brown (10YR 4/4) loamy sand, weak crumb structure 1-10 mm peds with weak consistence and a rough fabric.<br>Nil mottling, 5% pebbles 10-20 mm, abundant fine roots. Well drained with a clear and even boundary. |
| | B21<br>0.15 – 0.50 | Dark yellowish brown (10YR 4/6) light medium clay, moderate structure of 20-40 mm subangular blocky peds with a moderate consistence and a rough fabric.<br>20% distinct red mottles, 5% pebbles 10-20 mm, common coarse roots. Moderately drained with a gradual and even boundary. |
| | B22<br>+0.50 | Dark yellowish brown (10YR 4/6) light clay, moderate structure of 40-80 mm subangular blocky peds with a strong consistence and a rough fabric.<br>30% distinct grey mottles, 15% gravel 10-20 mm, few coarse roots. Moderately drained with a gradual and even boundary. |

**Table 15 Chemical Parameters: Subnatric Brown Sodosol (Site 5)**

| Layer (cm) | pH (1:5 water) | | ESP | | ECe (1:5) | | CEC | |
|---|---|---|---|---|---|---|---|---|
| | Unit | Rating | % | Rating | dS/m | Rating | cmol/kg | Rating |
| 0-10 | 6.0 | Moderately Acidic | 5.9 | Non-sodic | 0.2 | Non-saline | 6.8 | Low |
| 20-30 | 6.7 | Neutral | 14.4 | Strongly Sodic | 2.0 | Non-saline | 20.1 | Moderate |
| 50-60 | 7.1 | Neutral | 19.4 | Strongly Sodic | 4.7 | Moderately saline | 19.1 | Moderate |
| 65-75 | 7.6 | Mildly Alkaline | 19.9 | Strongly Sodic | 5.2 | Moderately saline | 18.6 | Moderate |

**Table 16 Summary: Mesonatric Brown Sodosol (Site 6)**

| Overview | |
|---|---|
|  | |
| **Landscape Site 6** | |
| **ASC Name** | Mesonatric Brown Sodosol |
| **Representative Site** | Site 6 |
| **Survey Type** | Detail |
| **Dominant Topography** | Lower Hillslope |
| **Current Land Use** | Cattle Grazing |
| **Vegetation** | Casuarina, Acacia, Paspalum |
| **Inherent Soil Fertility** | Moderately Low |
| **Slope** | 6% |

**Table 17 Profile: Mesonatric Brown Sodosol (Site 6)**

| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|   | A1<br>0.0 – 0.20 | Dark brown (7.5YR 3/3) loamy sand, weak crumb structure 1-10 mm peds with weak consistence and a rough fabric.<br>Nil mottling, <5% pebbles 10-20 mm, abundant fine roots. Well drained with a gradual and even boundary. |
| | A2<br>0.20 – 0.35 | Dark yellowish brown (10YR 4/4) bleached loamy sand, weak crumb structure 2-10 mm peds with weak consistence and a rough fabric.<br>Nil mottling, <5% pebbles 10-20 mm, abundant fine roots. Well drained with a clear and even boundary. |
| | B21<br>0.35 – 0.60 | Dark yellowish brown (10YR 4/6) light medium clay, moderate structure of 20-40 mm subangular blocky peds with a moderate consistence and a rough fabric.<br>20% distinct brown mottles; nil stone content, common coarse roots. Poorly drained with a gradual and even boundary. |
| | B22<br>0.60 – 1.10 | Dark yellowish brown (10YR 4/6) light clay, moderate structure of 40-80 mm subangular blocky peds with a strong consistence and a rough fabric.<br>20% distinct red and 20% distinct grey mottles, nil stone content, few coarse roots. Poorly drained with a gradual and even boundary. |
| | BC<br>+1.10 | Weathered parent material |

**Table 5 Chemical Parameters: Mesonatric Brown Sodosol (Site6)**

| Layer (cm) | pH (1:5 water) | | ESP | | ECe (1:5) | | CEC | |
|---|---|---|---|---|---|---|---|---|
| | Unit | Rating | % | Rating | dS/m | Rating | cmol/kg | Rating |
| 0-10 | 5.2 | Strongly Acidic | 3.3 | Non-sodic | 0.2 | Non-saline | 6.1 | Low |
| 20-30 | 6.1 | Slightly Acidic | 3.9 | Non-sodic | 0.1 | Non-saline | 5.1 | Very Low |
| 50-60 | 6.8 | Neutral | 18.2 | Strongly Sodic | 3.5 | Slightly saline | 18.7 | Moderate |
| 65-75 | 6.8 | Neutral | 19.3 | Strongly Sodic | 4.2 | Moderately saline | 16.6 | Moderate |

**Table 19 Summary: Subnatric Brown Sodosol (Site 8)**

| Overview | |
|---|---|
|  | |
| **Landscape Site 8** | |
| **ASC Name** | Subnatric Brown Sodosol |
| **Representative Site** | Site 8 |
| **Survey Type** | Detail |
| **Dominant Topography** | Drainage Flat |
| **Current Land Use** | Cattle Grazing |
| **Vegetation** | Ironbark, Stringybark, Wiregrass, Lantana |
| **Inherent Soil Fertility** | Moderately Low |
| **Slope** | 10% |

**Table 20 Profile: Subnatric Brown Sodosol (Site 8)**

| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|  | A1<br>0.0 – 0.05 | Brown (7.5YR 4/3) loamy sand, weak crumb structure 5-10 mm with weak consistence and a rough fabric.<br>Nil mottling, <5% pebbles 20 mm, abundant fine roots. Well drained with a gradual and even boundary. |
| | A2<br>0.05 – 0.20 | Dark yellowish brown (10YR 4/6) bleached loamy sand, weak crumb structure 5-10 mm with weak consistence and a rough fabric.<br>Nil mottling, <5% pebbles 20 mm, common fine roots. Well drained with a clear and even boundary. |
| | B21<br>0.20 – 0.60 | Dark yellowish brown (10YR 4/6) light medium clay, strong structure 20-40 mm subangular blocky peds with moderate consistence and a rough fabric.<br>30% distinct-red mottles, <5% pebbles 20 mm, common coarse roots. Poorly drained with a gradual and even boundary. |
| | B22<br>+0.60 | Yellowish red (5YR 4/6) medium clay loam, strong structure 20-40 mm subangular blocky peds with moderate consistence and a rough fabric.<br>20% distinct yellow mottles, <5% gravel 10-20 mm, few coarse roots. Poorly drained. |

**Table 21 Chemical Parameters: Subnatric Brown Sodosol (Site 8)**

| Layer (cm) | pH (1:5 water) | | ESP | | ECe (1:5) | | CEC | |
|---|---|---|---|---|---|---|---|---|
| | Unit | Rating | % | Rating | dS/m | Rating | cmol/kg | Rating |
| 0-5 | 5.2 | Strongly Acidic | 3.0 | Non-sodic | 0.2 | Non-saline | 6.6 | Low |
| 10-20 | 6.2 | Slightly Acidic | 2.3 | Non-sodic | 0.4 | Non-saline | 12.8 | Moderate |
| 25-35 | 5.8 | Moderately Acidic | 7.6 | Marginally Sodic | 0.9 | Non-saline | 17.0 | Moderate |
| 50-60 | 6.2 | Slightly Acidic | 9.0 | Marginally Sodic | 2.2 | Slightly Saline | 18.8 | Moderate |
| 65-75 | 6.9 | Neutral | 9.8 | Marginally Sodic | 4.7 | Moderately Saline | 16.4 | Moderate |

**Table 22 Summary: Brown Sodosol (Site 9)**

| Overview | |
|---|---|
|  | |
| **Landscape Site 9** | |
| **ASC Name** | Brown Sodosol |
| **Representative Site** | Site 9 |
| **Survey Type** | Check |
| **Dominant Topography** | Drainage Flat |
| **Current Land Use** | Cattle Grazing |
| **Vegetation** | Ironbark, Spotted Gum, Wiregrass, Lantana |
| **Inherent Soil Fertility** | Moderately Low |
| **Slope** | 5% |

**Table 23 Profile: Brown Sodosol (Site 9)**

| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|  | A1<br>0.0 – 0.10 | Dark brown (7.5YR 3/2) loamy sand, weak crumb structure 5-10 mm with weak consistence and a rough fabric.<br>Nil mottling, 10% gravel <10 mm, abundant fine roots. Well drained with a gradual and even boundary. |
| | A2<br>0.10 – 0.20 | Brown (7.5YR 5/4) bleached loamy sand, weak crumb structure 10-20 mm with weak consistence and a rough fabric.<br>Nil mottling, 10% gravel <10 mm, abundant fine roots. Well drained with a clear and even boundary. |
| | B21<br>0.20 – 0.50 | Brown (7.5YR 5/4) light medium clay, moderate structure 20-50 mm subangular blocky peds with moderate consistence and a rough fabric.<br>10% faint grey mottles, 10% gravel <10 mm, common coarse roots. Poorly drained with a gradual and even boundary. |
| | B22<br>+0.50 | Strong brown (7.5YR 5/6) medium clay, moderate structure 40-60 mm subangular blocky peds with moderate consistence and a rough fabric.<br>30% distinct grey mottles, 10% gravel <10 mm, common coarse roots. Poorly drained. Dispersive B22 horizon. |

**Table 24 Field Chemical Parameters: Brown Sodosol (Site 9)**

| Horizon | Field pH | | Dispersivity |
|---|---|---|---|
| | Unit | Rating | Rating |
| A1 | 6.0 | Moderately Acidic | Non |
| A2 | 6.0 | Moderately Acidic | Slightly |
| B21 | 7.0 | Neutral | Moderately |
| B22 | 9.0 | Strongly Alkaline | Highly |
| | | | |

**Table 25 Summary: Brown Sodosol (Site 10)**

| Overview | |
|---|---|
|  | |
| **Landscape Site 10** | |
| **ASC Name** | Brown Sodosol |
| **Representative Site** | Site 10 |
| **Survey Type** | Check |
| **Dominant Topography** | Mid Hillslope |
| **Current Land Use** | Cattle Grazing |
| **Vegetation** | Ironbark, Casuarina, Wiregrass, Lantana |
| **Inherent Soil Fertility** | Moderately Low |
| **Slope** | 8% |

**Table 26 Profile: Brown Sodosol (Site 10)**

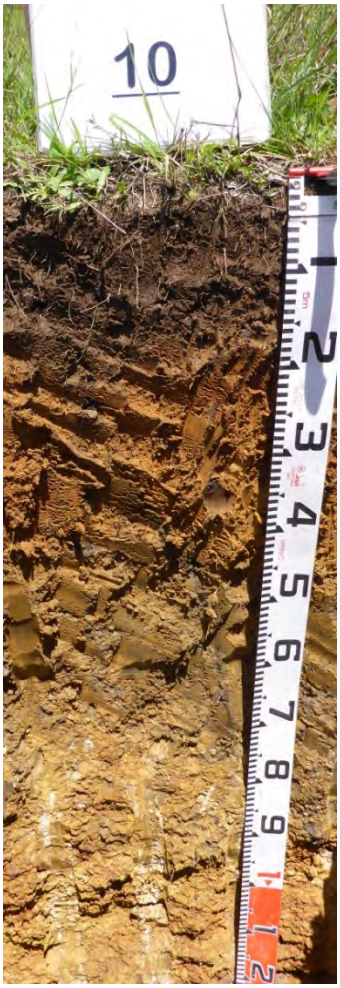
| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|  | A1<br>0.0 – 0.15 | Dark brown (7.5YR 3/2) sandy loam, weak crumb structure 5-10 mm with weak consistence and a rough fabric.<br>Nil mottling, 20% gravel 20 mm, abundant fine roots. Well drained with a clear and wavy boundary. |
| | B21<br>0.15 – 0.40 | Strong brown (7.5YR 5/6) medium clay, moderate structure 20-40 mm subangular blocky peds with moderate consistence and a rough fabric.<br>10% distinct brown mottling, 10% gravel 20 mm. Moderately drained with a gradual and wavy boundary. |
| | B22<br>0.40 – 0.70 | Brown (7.5YR 5/4) medium clay, moderate structure 20-40 mm subangular blocky peds with moderate consistence and a rough fabric.<br>30% distinct grey mottling, 10% gravel 20 mm. Poorly drained with a gradual and wavy boundary. Dispersive B22 horizon |
| | B23<br>0.70 – 1.0 | Reddish yellow (7.5YR 6/6) medium clay, moderate structure 60-80 mm subangular blocky peds with moderate consistence and a rough fabric.<br>30% distinct brown mottling, 50% gravel 20 mm, 20% hard calcium nodules 20 mm at +0.70. Poorly drained with a gradual and wavy boundary. Dispersive B23 horizon. |
| | BC<br>+1.00 | Weathered parent material |

**Table 27 Field Chemical Parameters: Brown Sodosol (Site 10)**

| Horizon | Field pH | | Dispersivity |
|---|---|---|---|
| | Unit | Rating | Rating |
| A1 | 6.0 | Moderately Acidic | Non |
| A2 | 7.0 | Neutral | Slightly |
| B21 | 8.0 | Moderately Alkaline | Moderately |
| B22 | 9.0 | Strongly Alkaline | Highly |
| B23 | 9.0 | Strongly Alkaline | Highly |
| | | | |

**Table 28 Summary: Subnatric Red Sodosol (Site 3)**

| Overview | |
|---|---|
|  | |
| **Landscape Site 3** | |
| **ASC Name** | Subnatric Red Sodosol |
| **Representative Site** | Site 3 |
| **Survey Type** | Detail |
| **Dominant Topography** | Mid Hillslope |
| **Current Land Use** | Cattle Grazing |
| **Vegetation** | Ironbark, Casuarina, Grevillea, Wiregrass |
| **Inherent Soil Fertility** | Moderately Low |
| **Slope** | 1% |

**Table 29 Profile: Subnatric Red Sodosol (Site 3)**

| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|  | A1<br>0.0 – 0.20 | Dark brown (7.5YR 3/3) loamy sand, weak crumb structure 2-5 mm peds with weak consistence and a rough fabric.<br>Nil mottling, <5% pebbles 10-20 mm, abundant fine roots. Well drained with a clear and wavy boundary. |
| | B21<br>0.20 – 0.35 | Yellowish red (5YR 4/6) heavy clay, moderate structure of 20-40 mm subangular blocky peds with a moderate consistence and a rough fabric.<br>30% distinct yellow mottles; nil stone content, common coarse roots. Moderately drained with a gradual and wavy boundary. |
| | B22<br>0.35 – 0.85 | Yellowish brown (10YR 5/6) medium clay, moderate structure of 40-80 mm subangular blocky peds with a moderate consistence and a rough fabric.<br>40% distinct red mottles, nil stone content, common coarse roots. Poorly drained with a clear and wavy boundary. |
| | BC<br>+0.85 | Weathered parent material |

**Table 30 Chemical Parameters: Subnatric Red Sodosol (Site 3)**

| Layer (cm) | pH (1:5 water) | | ESP | | ECe (1:5) | | CEC | |
|---|---|---|---|---|---|---|---|---|
| | Unit | Rating | % | Rating | dS/m | Rating | cmol/kg | Rating |
| 0-10 | 5.9 | Moderately Acidic | 2.5 | Non-sodic | 0.1 | Non-saline | 7.8 | Low |
| 20-30 | 5.7 | Moderately Acidic | 6.5 | Marginally Sodic | 0.4 | Non-saline | 18.6 | Moderate |
| 50-60 | 5.7 | Moderately Acidic | 11.0 | Sodic | 2.0 | Non-saline | 18.1 | Moderate |
| 65-75 | 7.5 | Mildly Alkaline | 14.7 | Strongly Sodic | 3.1 | Slightly Saline | 17.5 | Moderate |

**Table 31 Summary: Red Sodosol (Site 7)**

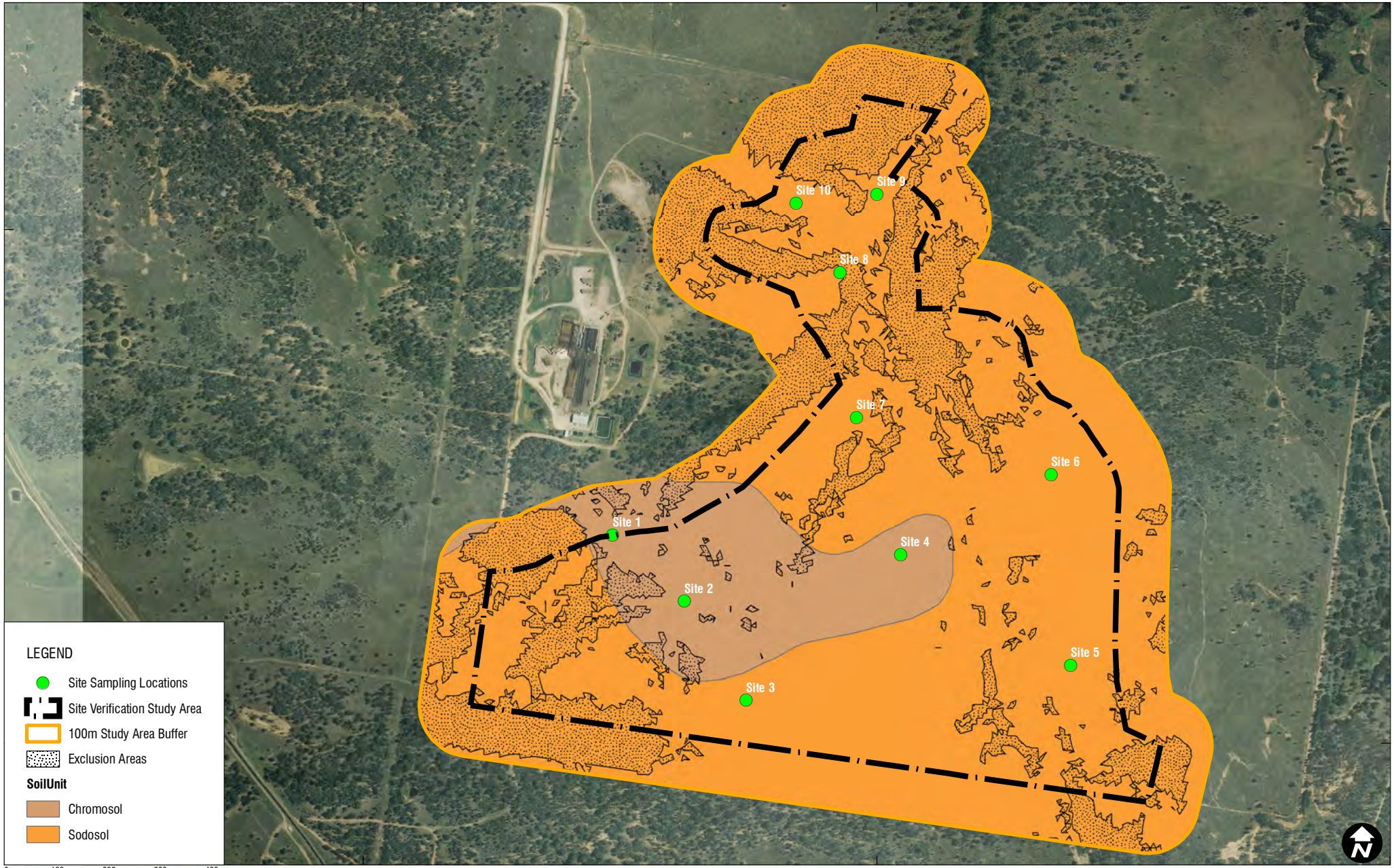
| Overview | |
|---|---|
|  **Landscape Site 7** | |
| **ASC Name** | Red Sodosol |
| **Representative Site** | Site 7 |
| **Survey Type** | Check |
| **Dominant Topography** | Mid Hillslope |
| **Current Land Use** | Cattle Grazing |
| **Vegetation** | Ironbark, Casuarina, Wiregrass, Lantana |
| **Inherent Soil Fertility** | Moderately Low |
| **Slope** | 8% |

**Table 32 Profile: Red Sodosol (Site 7)**

| Profile | Horizon / Depth (m) | Description |
|---|---|---|
|  | A1<br>0.0 – 0.10 | Dark brown (7.5YR 3/2) loamy sand, weak crumb structure 5-10 mm with weak consistence and a rough fabric.<br>Nil mottling, 20% pebbles 20 mm, abundant fine roots. Well drained with a gradual and wavy boundary. |
| | A2<br>0.10 – 0.20 | Brown (7.5YR 4/3) bleached loamy sand, weak crumb structure 5-10 mm with weak consistence and a rough fabric.<br>Nil mottling, 20% pebbles 20 mm, abundant fine roots. Well drained with a clear and wavy boundary. |
| | B21<br>0.20 – 0.40 | Yellowish red (5YR 5/6) medium clay, strong structure 20-40 mm subangular blocky peds with strong consistence and a rough fabric.<br>50% distinct-yellow mottles, 20% pebbles 20 mm, common coarse roots. Poorly drained with a gradual and even boundary. |
| | B22<br>0.40 – 0.85 | Yellowish brown (7.5YR 5/6) medium clay, strong structure 40-80 mm subangular blocky peds with strong consistence and a rough fabric.<br>10% faint grey mottles; 20% gravel 10-20 mm, few coarse roots. Poorly drained with a gradual and wavy boundary. |
| | B23<br>+0.85 | Reddish yellow (7.5YR 6/6) medium clay, strong structure 60-80 mm subangular blocky peds with strong consistence and a rough fabric.<br>20% faint red mottles; 20% gravel 10-20 mm, few coarse roots, <10% soft calcium nodules 10 mm at +0.85 m. Poorly drained. |

**Table 33 Field Chemical Parameters: Red Sodosol (Site 7)**

| Horizon | Field pH | | Dispersivity |
|---|---|---|---|
| | Unit | Rating | Rating |
| A1 | 6.0 | Moderately Acidic | Non |
| A2 | 6.0 | Moderately Acidic | Non |
| B21 | 6.0 | Moderately Acidic | Moderately |
| B22 | 5.5 | Strongly Acidic | Moderately |
| B23 | 9.0 | Strongly Alkaline | Highly |
| | | | |

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**Soil Units**

**FIGURE 5**

# 4 BIOPHYSICAL STRATEGIC AGRICULTURAL LAND ASSESSMENT

This BSAL assessment has been conducted in accordance with the Interim Protocol. The BSAL status was determined on the dominant soil type within each Soil Unit. The BSAL assessment and limitations for each soil sample site is shown in **Table 35**.

Two Soil Units were identified and mapped with the Study Area, and all were verified as non-BSAL due their failure of Criteria 7, 8 and 9. There is 103 hectares of land verified as non-BSAL within the Study Area based on the soil survey results (**Table 34**).

Additionally, with 40 hectares excluded as BSAL due to greater than 10% slope or being a contiguous area less than 20 hectares. Therefore the total Study Area has been mapped as non-BSAL.

**Table 34 BSAL Assessment Summary**

| Soil Survey BSAL Assessment | Area (hectares) |
|---|---|
| Verified BSAL | Nil |
| Verified Non-BSAL | 103 |
| Exclusion Zone (>10% slope) | 37 |
| Exclusion Zone (<20 hectares contiguous) | 3 |
| **Study Area Total** | **143** |

**Table 35 BSAL Assessment**

| Site | Soil Unit | Inspection Site Type | Soil Type: Australian Soil Classification (to ASC Great Group for detailed sites) | 1. Is slope < 10%? | 2. Is there < 30% Rock Outcrop? | 3. < 20% unattached Rock Fragments > 60mm? | 4. Does < 50% have Gilgais >500mm deep? | 5. Is Slope <5%? | 6. Are there nil rock outcrops? | 7a. Does soil have Moderate Fertility? | 7b. Does soil have Moderately High or High fertility? | 8. Is ERD to a physical barrier >750mm? | 9. Is drainage better than poor? | 10. Is pH (1:5 water) between 5.0 and 8.9? | 11. Is salinity (ECe) < 4 dS/m | 12. Is ERD to a chemical barrier >750mm? | Is the Soil Unit BSAL? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Sampled Sites** | | | | | | | | | | | | | | | | | |
| 1 | Chromosol | Detailed | Eutrophic Red Chromosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | No |
| 2 | | Detailed | Eutrophic Red Chromosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✓ | ✓ | |
| 4 | | Detailed | Eutrophic Brown Chromosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ | ✓ | ✓ | |
| 5 | Sodosol | Detailed | Subnatric Brown Sodosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ | ✗ | ✗ | |
| 6 | | Detailed | Mesonatric Brown Sodosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ | ✗ | ✗ | |
| 8 | | Detailed | Subnatric Brown Sodosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ | ✗ | ✓ | |
| 9 | | Check | Brown Sodosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | - | - | - | |
| 10 | | Check | Brown Sodosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | - | - | - | |
| 3 | | Detailed | Subnatric Red Sodosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | ✓ | ✓ | ✓ | |
| 7 | | Check | Red Sodosol | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✗ | ✗ | ✓ | ✗ | - | - | - | |

✓ = passes the BSAL criteria ✗ = fails the criteria but not excluded as BSAL ✗ = fails the BSAL criteria

N/A = criteria is not assessed in accordance with Interim Protocol

# 5 CONCLUSION

This BSAL Assessment for the Bulga Optimisation Project – Modification Area was undertaken by SLR Consulting. The Study Area for this BSAL Assessment is the proposed modified portion of the Modification Area, plus a 100 metre buffer totalled 143 hectares and contained no BSAL according to NSW Government criteria (DP&I, 2012).

Of the two soil units identified in the soil survey, the Chromosol failed the BSAL Criteria 9, poor drainage, which was evident through mottling and limited plant root growth in the B horizons. Site 2 also failed Criteria 8, soil depth. The Sodosol failed Criteria 7, having poor inherent fertility.

In summary the results of this BSAL Assessment are:

- An Exclusion Zone of 37 hectares, based on land greater than 10% slope were identified and excluded from the soil survey.
- An Exclusion Zone of 3 hectares, land areas less than 20 contiguous hectares total size were identified and excluded from the soil survey.
- Two soil units, a Chromosol and a Sodosol, comprising 103 hectares were identified during the soil survey and neither of these were considered to be BSAL.

Therefore it can be concluded that there is no qualifying BSAL within the Study Area.

# Appendix A

## Certificates of Analysis

Department of Primary Industries
Soil Conservation Service

# SOIL TEST REPORT



**Scone Research Centre**

---

| | |
|---|---|
| REPORT NO: | SCO16/014R1 |
| REPORT TO: | Murray Fraser<br>SLR Consulting<br>10 Kings Rd<br>New Lambton NSW 2305 |
| REPORT ON: | Twenty-six soil samples<br>Your ref: 630.11560 Bulga BSAL |
| PRELIMINARY RESULTS ISSUED: | Not issued |
| REPORT STATUS: | Final |
| DATE REPORTED: | 16 February 2016 |
| METHODS: | Information on test procedures can be obtained from Scone Research Centre |

TESTING CARRIED OUT ON SAMPLE AS RECEIVED


---

SR Young
(Laboratory Manager)

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO16/014R1
Client Reference: Murray Fraser
SLR Consulting
10 Kings Rd
New Lambton NSW 2305

| Lab No | Method | C1A/5 | C2A/4 | C2B/4 | C5A/4 CEC & exchangeable cations (cmol (+)/kg) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 1 | 1 0-10cm | 0.01 | 6.1 | 5.0 | 6.2 | 0.2 | 0.1 | 2.1 | 0.9 | <0.5 |
| 2 | 1 20-30cm | <0.01 | 6.5 | 5.2 | 6.0 | 0.2 | 0.1 | 1.7 | 0.8 | <0.5 |
| 3 | 1 40-50cm | 0.02 | 5.7 | 4.5 | 18.0 | 0.3 | 0.1 | 7.8 | 2.5 | 0.6 |
| 4 | 1 50-60cm | 0.03 | 5.7 | 4.6 | 16.9 | 0.4 | 0.2 | 8.2 | 2.1 | <0.5 |
| 5 | 1 65-75cm | 0.02 | 5.6 | 4.5 | 17.2 | 0.4 | 0.2 | 7.9 | 2.5 | 1.1 |
| 6 | 2 0-10cm | <0.01 | 5.8 | 4.6 | 4.8 | 0.2 | 0.7 | 1.9 | 1.0 | <0.5 |
| 7 | 2 20-30cm | <0.01 | 6.1 | 4.7 | 7.1 | 0.2 | 0.5 | 2.1 | 1.0 | <0.5 |
| 8 | 3 30-40cm | 0.01 | 5.8 | 4.7 | 18.7 | 0.3 | 0.5 | 9.9 | 2.1 | 1.0 |
| 9 | 2 50-60cm | 0.16 | 7.3 | 6.9 | 19.1 | 0.2 | 0.2 | 13.1 | 1.7 | nt |
| 10 | 3 0-10cm | <0.01 | 5.9 | 4.7 | 7.8 | 0.2 | 0.3 | 2.0 | 1.5 | <0.5 |
| 11 | 3 20-30cm | 0.07 | 5.7 | 4.5 | 18.6 | 1.2 | 0.4 | 2.1 | 8.4 | <0.5 |
| 12 | 3 50-60cm | 0.26 | 5.7 | 4.6 | 18.1 | 2.0 | 0.3 | 1.1 | 8.1 | <0.5 |
| 13 | 3 65-75cm | 0.36 | 7.5 | 6.5 | 17.5 | 2.6 | 0.5 | 1.0 | 7.8 | nt |
| 14 | 5 0-10cm | 0.01 | 6.0 | 4.7 | 6.8 | 0.4 | 0.2 | 1.0 | 1.7 | <0.5 |
| 15 | 5 20-30cm | 0.23 | 6.7 | 5.6 | 20.1 | 2.9 | 0.3 | 1.5 | 9.6 | nt |
| 16 | 5 60-60cm | 0.55 | 7.1 | 6.2 | 19.1 | 3.7 | 0.2 | 1.6 | 8.3 | nt |
| 17 | 5 65-75cm | 0.61 | 7.6 | 6.6 | 18.6 | 3.7 | 0.4 | 1.1 | 7.7 | nt |
| 18 | 6 0-10cm | 0.01 | 5.2 | 4.2 | 6.1 | 0.2 | 0.2 | 1.1 | 1.4 | <0.5 |
| 19 | 6 20-30cm | <0.01 | 6.1 | 4.9 | 5.1 | 0.2 | 0.1 | 0.6 | 1.4 | <0.5 |
| 20 | 6 50-60cm | 0.41 | 6.8 | 5.8 | 18.7 | 3.4 | 0.5 | 1.7 | 6.9 | nt |
| 21 | 6 65-75cm | 0.49 | 6.8 | 5.9 | 16.6 | 3.2 | 0.5 | 0.9 | 5.8 | nt |
| 22 | 8 0-5cm | 0.01 | 5.2 | 4.2 | 6.6 | 0.2 | 0.2 | 1.2 | 1.3 | <0.5 |
| 23 | 10-20cm | 0.05 | 6.3 | 5.2 | 12.8 | 0.3 | 0.6 | 2.6 | 2.7 | <0.5 |
| 24 | 25-35cm | 0.10 | 5.8 | 4.8 | 17.0 | 1.3 | 0.3 | 5.1 | 5.3 | <0.5 |
| 25 | 50-60cm | 0.26 | 6.2 | 5.4 | 18.8 | 1.7 | 0.2 | 4.8 | 5.7 | <0.5 |
| 26 | 65-75cm | 0.55 | 6.9 | 6.2 | 16.4 | 1.6 | 0.3 | 3.9 | 4.9 | nt |

nt = not tested

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO16/014R1
Client Reference: Murray Fraser
SLR Consulting
10 Kings Rd
New Lambton NSW 2305

| Lab No | Method | P7B/2 Particle Size Analysis (%) | | | | | Colour | |
|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | Dry | Moist |
| 1 | 1 0-10cm | 5 | 13 | 49 | 33 | <1 | 7.5YR 5/3 | 7.5YR 3/4 |
| 2 | 1 20-30cm | 5 | 14 | 47 | 32 | 2 | 7.5YR 6/4 | 7.5YR 4/6 |
| 3 | 1 40-50cm | 48 | 11 | 20 | 21 | <1 | 7.5YR 5/8 | 5YR 5/8 |
| 4 | 1 50-60cm | 38 | 20 | 30 | 12 | <1 | 7.5YR 6/8 | 7.5YR 5/8 |
| 5 | 1 65-75cm | 46 | 12 | 20 | 22 | <1 | 7.5YR 6/6 | 7.5YR 5/8 |
| 6 | 2 0-10cm | 5 | 14 | 49 | 31 | 1 | 7.5YR 5/4 | 7.5YR 4/4 |
| 7 | 2 20-30cm | 7 | 14 | 45 | 28 | 6 | 7.5YR 5/4 | 7.5YR 4/6 |
| 8 | 3 30-40cm | 49 | 14 | 28 | 9 | <1 | 5YR 5/8 | 2.5YR 4/8 |
| 9 | 2 50-60cm | 31 | 11 | 22 | 29 | 7 | 7.5YR 5/8 | 5YR 4/6 |
| 10 | 3 0-10cm | 5 | 16 | 66 | 12 | 1 | 10YR 5/3 | 7.5YR 3/3 |
| 11 | 3 20-30cm | 54 | 12 | 29 | 5 | <1 | 7.5YR 5/6 | 5YR 4/6 |
| 12 | 3 50-60cm | 47 | 12 | 35 | 6 | <1 | 10YR 6/6 | 10YR 5/6 |
| 13 | 3 65-75cm | 39 | 16 | 37 | 8 | <1 | 7.5YR 6/6 | 7.5YR 5/6 |
| 14 | 5 0-10cm | 7 | 23 | 57 | 8 | 5 | 10YR 5/3 | 10YR 4/4 |
| 15 | 5 20-30cm | 43 | 14 | 35 | 7 | 1 | 10YR 5/6 | 10YR 4/6 |
| 16 | 5 60-60cm | 31 | 10 | 38 | 8 | 13 | 10YR 5/6 | 10YR 4/6 |
| 17 | 5 65-75cm | 32 | 11 | 43 | 10 | 4 | 10YR 5/6 | 10YR 4/6 |
| 18 | 6 0-10cm | 8 | 15 | 67 | 9 | 1 | 7.5YR 4/3 | 7.5YR 3/3 |
| 19 | 6 20-30cm | 5 | 15 | 68 | 8 | 4 | 10YR 6/3 | 10YR 4/4 |
| 20 | 6 50-60cm | 45 | 8 | 44 | 3 | 0 | 10YR 6/6 | 10YR 4/6 |
| 21 | 6 65-75cm | 37 | 10 | 48 | 5 | <1 | 10YR 6/6 | 10YR 4/6 |
| 22 | 8 0-5cm | 8 | 14 | 66 | 9 | 3 | 7.5YR 5/3 | 7.5YR 4/3 |
| 23 | 10-20cm | 27 | 11 | 52 | 9 | 1 | 10YR 8/4 | 10YR 4/6 |
| 24 | 25-35cm | 40 | 11 | 42 | 6 | 1 | 10YR 6/6 | 10YR 4/6 |
| 25 | 50-60cm | 38 | 12 | 39 | 8 | 3 | 7.5YR 6/8 | 7.5YR 5/8 |
| 26 | 65-75cm | 32 | 14 | 43 | 9 | 2 | 5YR 5/8 | 5YR 4/6 |

END OF TEST REPORT

Department of Primary Industries
Soil Conservation Service

# SOIL TEST REPORT



**Scone Research Centre**

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| | |
|---|---|
| REPORT NO: | SCO16/019R1 |
| REPORT TO: | Murray Fraser<br>SLR Consulting<br>10 Kings Rd<br>New Lambton NSW 2305 |
| REPORT ON: | Twenty-six soil samples<br>Your ref: 630.11560 Bulga BSAL |
| PRELIMINARY RESULTS ISSUED: | Not issued |
| REPORT STATUS: | Final |
| DATE REPORTED: | 16 February 2016 |
| METHODS: | Information on test procedures can be obtained from Scone Research Centre |

TESTING CARRIED OUT ON SAMPLE AS RECEIVED


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SR Young
(Laboratory Manager)

**SOIL CONSERVATION SERVICE**
**Scone Research Centre**



Report No: SCO16/019R1
Client Reference: Murray Fraser
SLR Consulting
10 Kings Rd
New Lambton NSW 2305

| Lab No | Method | C1A/5 | C2A/4 | C2B/4 | C5A/4 CEC & exchangeable cations (cmol (+)/kg) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sample Id | EC (dS/m) | pH | pH ($CaCl_2$) | CEC | Na | K | Ca | Mg | Al |
| 1 | 4 0-10 | <0.01 | 5.1 | 4.2 | 6.4 | 0.1 | 0.2 | 0.6 | 1.4 | <0.5 |
| 2 | 4 20-30 | <0.01 | 5.6 | 4.4 | 5.4 | 0.2 | <0.1 | 0.5 | 1.4 | <0.5 |
| 3 | 4 35-45 | 0.12 | 6.4 | 5.7 | 25.0 | 1.1 | 0.1 | 12.1 | 4.5 | nt |
| 4 | 4 50-60 | 0.27 | 8.4 | 7.6 | 31.1 | 1.3 | 0.3 | 16.1 | 4.7 | nt |
| 5 | 4 65-75 | 0.18 | 8.7 | 7.9 | 26.2 | 1.2 | 0.5 | 17.5 | 4.0 | nt |

nt = not tested

| Lab No | Method | P7B/2 Particle Size Analysis (%) | | | | | Colour | |
|---|---|---|---|---|---|---|---|---|
| | Sample Id | clay | silt | f sand | c sand | gravel | Dry | Moist |
| 1 | 4 0-10 | 5 | 10 | 59 | 26 | <1 | 7.5YR 5/3 | 7.5YR 3/3 |
| 2 | 4 20-30 | 3 | 10 | 57 | 26 | 4 | 7.5YR 6/3 | 7.5YR 4/6 |
| 3 | 4 35-45 | 52 | 7 | 29 | 12 | <1 | 10YR 5/8 | 10YR 4/6 |
| 4 | 4 50-60 | 45 | 11 | 27 | 14 | 3 | 10YR 5/6 | 10YR 4/6 |
| 5 | 4 65-75 | 34 | 11 | 28 | 22 | 5 | 7.5YR 6/6 | 7.5YR 5/8 |

END OF TEST REPORT

# Appendix B

## Slope Analysis

# Slope Analysis Methodology

***Methodology***

1. Acquire appropriate elevation information. In this case, LIDAR data provided by Bulga Coal Complex.

2. Load Contours into ArcMap 10.3

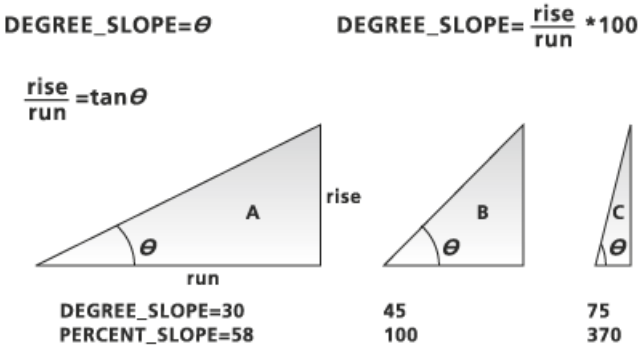
3. Using 3D Analyst Extension - Create a TIN Surface based on the contours (http://resources.arcgis.com/en/help/main/10.1/index.html#/Create_TIN/00q90000001v000000/)

4. Using 3D Analyst Extension – Run the Surface Slope Tool (http://resources.arcgis.com/en/help/main/10.1/index.html#//00q900000076000000) using a custom Break File (attached).

5. Using a Spatial Join, correlate the Surface Slope at the Soil Survey coordinates.

***The Surface Slope Tool***

**Surface Slope** creates an output polygon feature class containing polygons that classify an input TIN or terrain dataset by slope. The slope is the angle of inclination between the surface and a horizontal plane, which may be analysed in degrees or percent. Slope in degrees is given by calculating the arctangent of the ratio of the change in height (dZ) to the change in horizontal distance (dS), or slope = Arctan (dZ/dS). Percent slope is equal to the change in height divided by the change in horizontal distance multiplied by 100, or (dZ/dX) * 100.




The {**slope_field**} is the name of attribute field used to record the polygon aspect codes. Its default value is SlopeCode.

Each triangle is classified into a slope class. Contiguous triangles belonging to the same class are merged during the formation of output polygons. The {units} parameter can be set to use PERCENT or DEGREES. The default is PERCENT. The default percent slope class breaks are 1.00, 2.15, 4.64, 10.00, 21.50, 46.40, 100.00, 1000.00. Optionally, DEGREES may be used to classify slope. The default degree slope class breaks are 0.57, 1.43, 2.66, 5.71, 12.13, 24.89, 45.0, 90.0.

The {**class_breaks_table**} is used to define custom slope classes. The table can be either a TXT or DBF file for a Windows environment, and a DBF file in a UNIX environment. Each record in the table needs to contain two values that are used to represent the slope range of the class and its corresponding class code.

Table example:

```
break, code

  10.0, 11

  25.0, 22

  40.0, 33

  70.0, 44
```

Note the comma delineation and use of decimals in the first field. Field names are needed but are ignored. The first field represents the breaks and values need to be decimal, the second field represents codes and values need to be integer. The units of the slope range are defined by the {units}. When this argument is not specified, the default classification is used.